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*Performance Testing of Wheel Bearing Lubricants**

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I. Introduction

This paper covers cooperative work conducted by the Coordinating Research Council, through its CLR General Grease Program and Analysis Group, in response to an urgent request by the U. S. Army Ordnance Department. It so happened that I was appointed chairman of the special Panel for this project, designated "CLLG-25, Recommendations Relative to Performance Tests on Wheel Bearing Lubricants." This Panel was organized with representation from the following twelve laboratories:

California Research Corporation
Gulf Research & Development Company
Kendall Refining Company
Pure Oil Company
Quaker State Oil Refining Corporation
Rock Island Arsenal
Sinclair Refining Company
Socony-Vacuum Oil Company
Standard Oil Development Company
Standard Oil Company (Indiana)
The Texas Company
Tide Water Associated Oil Company

I take pleasure in presenting the results of the united efforts of this Group which has so diligently functioned under the auspices of the CRC.

II. Need for Performance Test

The need for a performance test upon U. S. Army Specification 2-108 Greases was first recognized when it was noted that certain greases manufactured in other countries and which met the specification were, in certain cases, unsatisfactory in service. Subsequent observations in the United States also indicated that greases could meet the subject specification in its entirety and yet prove inferior in wheel bearing applications. The following are typical of observations received from the field:

(1) Apparently the adhesive characteristics of this grease are not what they should be since a bearing carefully and thoroughly cleaned and dried and as carefully and thoroughly packed and adjusted is practically greaseless after a few revolutions of the wheel. The grease unwinds itself out of the spaces between the bearing and into the axle housing just as though it were a piece of yarn being pulled out.

(2) After a short operation of the vehicle the bearings appear to be dry and no adherence of the grease, either to the rollers or to the races, is noticeable. The grease appears to knit and adhere perfectly to itself but departs from the bearings and it seems to work itself out from the bearings and fills up the hub cavity.

(3) Mortalities of wheel bearings have become exaggerated beyond reasonable expectancies and are not altogether due to the type of service which they are receiving. Inner and outer races are pitting and the ground surface flaking at the point of pitting. Close observance at intervals of 100 to 1000 miles discloses that the lubricant does not have adhesive qualities necessary to lubricate the bearing surfaces. After short intervals of operation the bearing races and rollers are dry.

III. Program of Panel

It was recognized by the Panel that various apparati, more or less complicated, had long been in use by the manufacturers of wheel bearing greases for evaluation of their respective products. It seemed desirable, in this case, to select a simple and relatively inexpensive type of test machine that could be made available to all suppliers and which would give a reliable indication of service characteristics, applicable to greases covered by the current items of U. S. Army Specification 2-108, as shown below:

1. Tendency of grease as such, or of separated oil, to leak from the wheel bearing in service.
2. Ability of the hot grease to hold its form in the hub.
3. Tendency of grease toward abnormal consistency changes in drastic service.
4. Tendency of grease to separate oil or soap in drastic service.
5. Tendency of grease to fail to lubricate bearings, i.e., to allow balls or rollers to run dry, although adequate grease remains in the hub.
6. Tendency of grease to form deposits upon the bearings or races.

With the above in mind, a detailed study was made of laboratory assemblies of both Ford and Chevrolet front wheels and bearings in setups typifying various wheel bearing lubricant testers already extant and upon which appreciable background was available. Greases of good and bad service behavior were employed as a basis for evaluation of the test mechanisms. As a result of this study, a hub of special design was developed.

*Courtesy The S.A.E. Journal.

IV. Description of Apparatus

The tester (Figure 1) consisting of a front wheel hub fitted with 1933 Ford races and bearings, is driven at 430 rpm (equivalent to 40 mph) by means of a V belt and motor encased in an insulated removable hood. Means for thermostatically controlling the temperature has been built into the base of the device to make it completely self contained. A fan on the motor shaft circulates air over the heaters and hub. The regular grease retainer is not used and in its place is a ring for catching any grease which leaks from the inner end of the hub. This is removable and provides a method of determining the grease loss. This grease catching ring slips over the spindle and is held in place by the large bearing. The regular grease retainer is not used for two reasons: (1) it is desirable in a laboratory test to accelerate any leakage which may occur and (2) defective retainers are found in actual service.

It was originally believed the machine could either be satisfactorily fabricated by individual shops or purchased from a supplier. However, experience gained in correlative tests employing commercial hubs of several makes, several specially made hubs, and the first experimental model of the machine built by an apparatus supplier served to emphasize the necessity for detailed consideration to the hub and spindle assembly if test results were to be reproducible. Furthermore, these correlative tests demonstrated not only the need for care upon hub and spindle but also upon insulation, heat loss through the spindle support, and actual temperatures attained in the back bearing as indicated by thermocouple measurements taken through the rear of the spindle, bored to a depth of 1-½". (Spindles of all machines are therefore so drilled for this purpose).

Figure 1

It is upon this basis therefore that recommendation was made in the interest of uniformity of results (repeatability and reproducibility) that all machines be purchased from one supplier.

V. Test Procedure*

A total of ninety grams of grease are used for each test. The bearings are carefully packed by hand with approximately five grams of grease (about 2.0 and 3.0 grams in the smaller and larger bearings, respectively) and the balance is placed in a uniform layer on the inside of the hub. A very thin film of grease is applied to the outer races contained in the hub. The ninety grams of grease fills the hub practically even with the wheel races and, with the exception of very fibrous greases, can be readily and uniformly distributed by use of a small spatula.

The leakage cup is placed in position and the large or inner bearing, packed with the grease being tested, is next placed in its proper position on the spindle. The wheel and outer or small bearing are then put on, followed by the loose fitting retainer washer and the castellated nut for holding the wheel assembly in place. The assembly is tightened until the wheel ceases to coast when spun by hand and the castellated nut is then slacked off until the wheel rotates quite freely without end play (approximately (one-sixth of a turn). The hub is then locked in place by insertion of the cotter pin. After the hub cap is screwed on, the V-belt is finally put into place and the cover closed.

When the apparatus is thus assembled the motor and both heaters are turned on. Each test is run for six hours from the time the motor is started and the heat switched on. (In case of questionable results in a six-hour run a second test of sixteen hours' duration can be made, the same requirements being imposed upon the lubricant. The need for the longer period of test will be found in rare instances only).

The temperature of the spindle is brought to and maintained at a temperature of 220°F. This will be attained by an ambient temperature near the hub of approximately 235°F., varying somewhat with room temperature, air currents, etc. This temperature should be reached in a maximum of 30 minutes, 20 minutes generally being adequate. An ambient of 235°F. will be held with the continuous heater on and the intermittent cutting out at about 235°F.

*Copies obtainable from Coordinating Research Council, Inc., under Designation L-24-745, "Test Procedure for Determining Performance Characteristics of Wheel Bearing Lubricants."

VI. Evaluation of Grease

The grease at the end of the six-hour running period is evaluated by the following criteria:

1. The apparatus, immediately at the conclusion of the test, is dismantled and the wheel inclined upon the bench, resting upon the edge of the pulley and outer hub. Flowage of grease from the hub shall not, per se, be cause for rejection, so long as the material is still of grease consistency. However, abnormal loss of grease consistency to the extent of becoming quite thin or "puddling" shall be cause for rejection.
2. Abnormal change of grease structure from the original shall be cause for rejection. (This refers to either smooth or short fiber grease assuming a very fibrous ropy structure, "setting up," gelatinizing, or forming a dry brittle gel structure.
3. Leakage in excess of 10 grams (11%) of grease and/or oil into the grease retainer at the back of the hub shall be cause for rejection.
4. Any adherant deposit of varnish, gum, or lacquer-like nature upon the bearings or races which is in evidence after slushing for two minutes at room temperature in naphtha (as specified in ASTM Method D-91-40) for removal of the grease film shall be cause for rejection.

VII. Lubricants Tested

A total of eighteen lubricants of good or bad service behavior were studied as listed below:

Sample	*Source*	*Supplier's Information*
G-90	Cooperator	Good
G-91	Cooperator	Bad
G-92	Ordnance	Very questionable
G-93	Ordnance	Very questionable
G-94	Ordnance	Bearing Failures
G-95	Ordnance	Unknown
G-96	Ordnance	Unknown
G-97	Cooperator	Good
G-98	Cooperator	Bad
G-99	Ordnance	Questionable
G-100	Ordnance (Foreign)	Questionable
G-101	Ordnance (Foreign)	Questionable
G-102	Ordnance (Foreign)	Questionable
G-103	Cooperator	Good
G-104	Cooperator	Bad
G-105	Cooperator	?
G-106	Cooperator	?
G-109	Cooperator	Good

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VIII. Original Data

The original data obtained upon the eighteen test greases are shown in the attached Table I, the starred items indicating reasons for failure. It will be noted that every grease of questionable or bad service history in the experience of the supplier was failed in the test. In only one case was a grease reputed to be satisfactory in service rated as failing.

Photographs taken at the conclusion of certain of these tests are shown in the attached Figures 2-7, inclusive, and typify the following:

Figure 2—A perfect test.

Figure 3—Transposition from an originally very smooth structure to a very fibrous, ropy condition. Slight deposit on bearings.

Figure 4—Separation of free oil. Tendency to gel.

Figure 5—29% leakage. Extreme "puddling." Large deposit on bearings. Noisy running.

Figure 6—21% leakage. "Puddling." Slight deposit on bearings.

Figure 7—A perfect test.

IX. Cooperative Data

It appeared at this stage that the test under study was indeed indicative of service behavior. However, before proceeding further it was felt that these same greases should be tested in machines of other design long used by various members of the Panel for evaluation of wheel bearing lubricants. Table II shows a summary of the resulting data, the starred items indicating ratings in disagreement with those secured upon the final model of the tester, in use at that time in two laboratories. While there are a few discrepant results it is believed this is partly due to divergent ideas as to what is required of a grease for satisfactory wheel bearing lubrication.

X. Present Status

With this background an equipment manufacturer was authorized to build these machines. A total of sixteen have been fabricated and delivered to as many laboratories. Another lot of 25 are practically completed.

Coordinating tests are now under way upon the original sixteen machines and preliminary data look very uniform.

XI. Conclusions

This test, as proposed, is fairly liberal. Many of us believe, in contrast to the 10 grams allowable, that no leakage from the inner bearing should be tolerated. Some feel that migration of grease to the front of the hub is bad. Others would go further and not only fail greases that "puddle" or flow as liquid from the hub upon dismantling, but also those that slump from the hub in a mass which is still of grease consistency. A few cooperators feel the test should be of longer duration than six hours. We, in our own Laboratory, have however never found a grease that failed at the end of a sixteen-hour test that would not also have been eliminated at the conclusion of a six-hour period.

Final agreement upon details of procedure and interpretation of results as noted above must, we believe, await the accumulation of greater experience with this machine upon the part of Industry through cooperative effort.

Figure 2

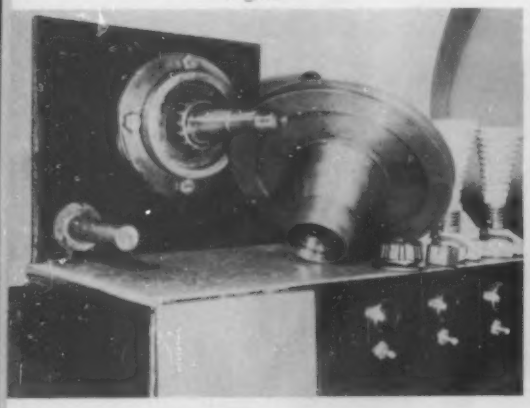


Figure 3

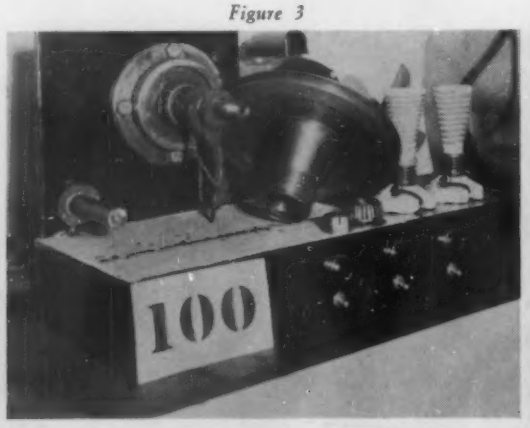


Figure 4

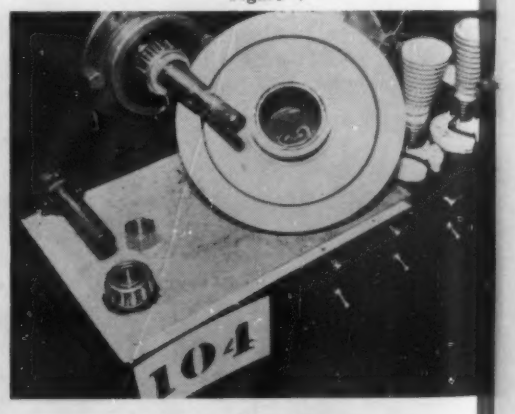


Figure 5

Figure 6

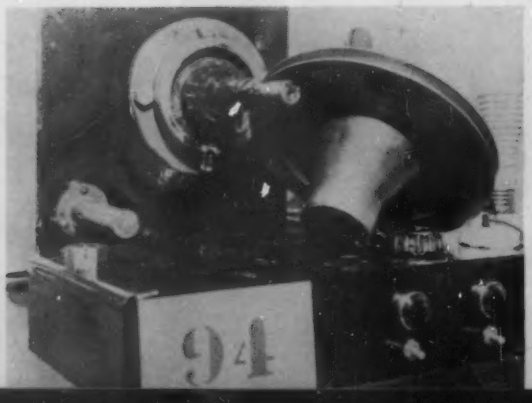


Figure 7

TABLE I

ORIGINAL DATA ON PROPOSED TESTER

CLLG No.	Appearance	Lubrication	Deposit	Leakage, %	Flowage From Hub	Flowage From Spindle	Remarks	Rating	Service
90	Green—smooth fibre	O.K.	None	None	Holds form	None on	.....	Pass	Good
91	Yellow—fibrous	O.K.	None	0.5	*Runs out—foamy	Drops off	.....	Fail	Bad
92	Brown—fibrous	O.K.	None	*10	*Runs out	Some drops off	Difficult to pack	Fail	V. Dubious
93	Black—fibrous	Dubious	*Slight	*21	*Runs out	Thin film—stays on	.....	Fail	V. Dubious
94	Black—V. fibrous	V. Poor	*Much	*29	*Runs out	Thin film—stays on	Difficult to pack. V. noisy	Fail	Bad—failures
95	Black—grainy	Dubious	*Slight	None	*Slumps out	Some drops off	.....	Fail	Unknown
96	Green—fibrous	O.K.	None	*22	*Runs out	Some drops off	.....	Fail	Unknown
97	Green—smooth	O.K.	None	None	Holds form	None	.....	Pass	Good
98	Green—fibrous	O.K.	None	*11	*Slumps out	Stays on	.....	Fail	Bad
99	Black—fibrous	Dubious	*Slight	*4.5	*Runs out	Drops off	.....	Fail	Dubious
100	Brown—smooth	Dubious	*Slight	*(5—front)	Little in hub	*Heavy, fibrous, stringy	Gets very fibrous and heavy	Fail	Dubious
101	Brown—fibrous	Dubious	*Slight	Trace	*Runs out	Drops off	.....	Fail	Dubious
102	Brown—fibrous	O.K.	None	*17.3	Holds form	Stays on	.....	Fail	Dubious
103	Green—fibrous	O.K.	None	None	*Runs out	Drops off	.....	Fail	Good
104	Yellow—fibrous	O.K.	None	Trace	*Free oil—slumps	Small amount—drops off	*Gels	Fail	Bad
105	Amber—fibrous	O.K.	None	None	Holds form	None	*Sets up cold	Pass (?)	.....
106	Green—fibrous	O.K.	None	None	*Runs out—foamy	Considerable—some drops off	.....	Fail	.....
109	Green—smooth fiber	O.K.	None	None	Free oil—slumps	None	*Gels	Pass	Good

*Reasons for failure.

However, the test as at present agreed upon will in the meantime eliminate inferior wheel bearing lubricants. If conscientiously employed by suppliers it is believed that the average quality of wheel bearing greases will be markedly improved and that the "headaches" of both supplier and consumer due to poor field performance will be alleviated, if not obviated.

TABLE II

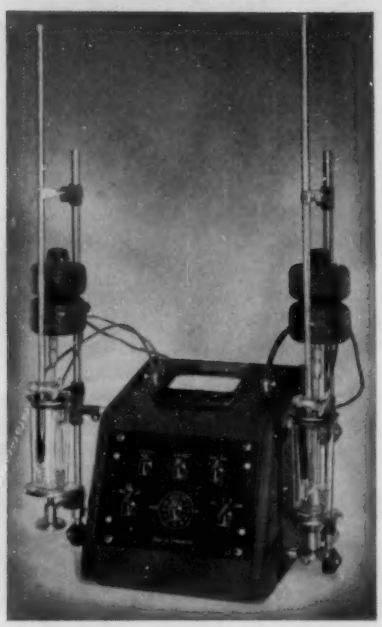
SUMMARY OF ALL DATA

Laboratory Sample	Proposed Testers: Final Model A	B	Lab. C Model C	D	Other Machines: E	F	G
G-90	P	P	P	P	P	P	P
G-91	F	F	F	F	—	F	F
G-92	F	F	F	F	—	F	F
G-93	F	F	F	F	—	F	F
G-94	F	F	F	F	F	F	F
G-95	F	F	F*	F	—	F	P*
G-96	F	F	F	F	—	F	F
G-97	P	P	P	P	—	F*	P
G-98	F	F	P*	F	—	F	F
G-99	F	—	—	—	—	—	—
G-100	F	—	—	—	—	P	—
G-101	F	—	—	—	—	—	—
G-102	F	—	—	—	—	—	—
G-103	F	F	P*	F	F	P*	F
G-104	F	F	F	F	F	F	P*
G-105	P	—	—	—	—	—	—
G-106	F	—	—	—	—	—	—
G-109	P	—	—	—	—	—	—

P=Pass; F=Fail

* Tests not agreeing with rating given greases upon final model of tester in A and B Laboratories.

TESTING ★ TOPICS



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